ness was really in dispute, and how much Peach's observations went to settle it. No one reading the volume, with its account of Dick's hammerings and Hugh Miller's visits and writings, could surmise that in the palæontology of the Old Red Sandstone of Caithness Peach has done far more than Dick, far more than Hugh Miller, more, indeed, than all other geologists put together.

The illustrations of Caithness scenery, plentifully interspersed throughout the book, are well engraved, and, on the whole, very faithful and characteristic. Nothing could be better than the Deil's Brig of Scrabster Bay. We see the very lichens quivering in the gusts that blow for ever through that hideous cleft, and we hear the screams of the northern sea-fowl as they wheel in restless circles from the neighbouring Clett. In transferring the author's sketches to the wood, however, the artists have taken a few liberties which would have roused poor Dick's indignation. Dirlet Castle, which stands on a rock some twenty or thirty feet above the stream, is raised at least 300 feet into the air; and dear old Morven, glorified into a second Matterhorn, is placed just opposite to Dick's contemptuous ridicule of what the books say about the hill—"None of the hills are as big as books make them"—"downright nonsense! Morven is accessible on every side." ARCH. GEIKIE

TELEGRAPHY

Instructions for Testing Telegraph Lines and the Technical Arrangements of Offices. By Louis Schwendler. (London: Trübner and Co., 1878.)

THE criterion of the good working of a line of telegraph is its freedom from interruption. Interruptions to the communication are technically called "faults," and on our overground lines men are stationed at certain intervals for the express purpose of patrolling these lines and removing defects from them that sooner or later might culminate in faults. Of course accidents, such as those arising from snowstorms and violent winds, cannot be prevented, but most of the interruptions that are met with in practice can by proper supervision be eliminated before they can arrive at such a condition as to interfere with the communication. In telegraphy more than in anything else, "prevention is better than cure," and for many years past all our telegraph engineers who have devoted their attention to the proper maintenance of telegraphs have striven to devise as perfect a method as they can for detecting the presence of faults and for establishing an accurate system of testing.

It is, however, upon our submarine cables, not only in their manufacture but during the process of laying, and whilst subsequently working, that the greatest skill and ingenuity has been employed to devise a perfect system of testing.

The first rational mode of testing our cables was introduced by Dr. Siemens, but Mr. Varley had previously introduced into the service of a Telegraph Company a very elaborate system of testing by the aid of differential galvanometers and resistance coils. Rheostats or resistance coils had been invented by Wheatstone as far back as 1843, and Sir Charles Bright and his brother, Mr. Edward Bright, had introduced them into use on the Magnetic Telegraph Company's system. It was, however, in the telegraph companies' service that the system was to a certain extent perfected, and when all the systems of the different companies were concentrated into the hands of the General Post Office the system became universal for the whole country. We cannot think that Mr. Schwendler, when he asserts that no really practical system of testing had been adopted by any other telegraphic administration than that of India, could have been aware of the perfect system in use by our English administration, and it is a pity that he has not embodied in his book a description of the system in use in England. This perhaps is unnecessary, because it is fully detailed in the "Handbook of Practical Telegraphy," by Mr. Culley, and in the text-book of science on "Telegraphy," by Messrs. Preece and Sivewright. Moreover, there is an excellent little "Handbook of Testing" detailing not only the practice on land lines but on cables also, by Mr. H. R. Kempe, and with another capital little book by Capt. Hoskiaer, on "testing cables," as well as a work on "Electrical Measurements," by Mr. Latimer Clark, leaves very little to be desired on the literature of the subject. Mr. Schwendler really adds little or nothing to our knowledge of the subject, and his book is only valuable as an indication of what has been done in India.

Great strides have been made in the Telegraphic Department in India ever since the accession to power of the lamented Col. Robinson. There is, according to Mr. Schwendler, a large staff of officers available with a first-rate general education and with a strong desire for improvement, and many of them are well trained in conducting physical experiments. It is to be hoped that their education is sufficiently advanced to enable them to follow the rather intricate mathematical developments of Mr. Schwendler. If his book has a defect it is that it is overloaded with mathematical investigations. There is no necessity to appeal to laboured formulæ when simple observations alone are needed to interpret phenomena. The mathematician loves his formulæ as a hen her brood, but the practical man prefers to kick them aside when he can do so and when he can do without them. Now, at p. 16, Mr. Schwendler gives no less than six elaborate formulæ, one of which must be selected for each particular condition to enable the tester to discover the value of any foreign electromotive force that may be in the circuit, the result of what he calls a "natural" current. Now there is no necessity whatever for any formula. The elimination of earth currents in cable and land testing is of daily and constant occurrence, and it is only necessary to compare the deflection upon any galvanometer given by the earth current with a deflection produced by one cell through similar resistance to find its value. Readings by reversals when taken rapidly always give a mean that is approximately true, for an earth current rarely varies so rapidly as to introduce any sensible error. His formulæ for eliminating the electromotive force when measuring with a differential galvanometer simply appal one.

Mr. Schwendler wisely says, "however much testing may become routine by continual practice it *will* always and *should* always partake of something of the nature of a physical experiment which must be conducted with a perfectly clear understanding. Then only can the tester draw the right conclusions from his observed facts; then

only can testing become a real benefit to the administration."

Again he says, "We know quantitatively the electrical state of the lines at all hours of the day, and seasons of the year; we are able to localise faults of all kinds very accurately and repair them with despatch; we test all our telegraphic material, and by it have greatly improved its essential qualities; we are not groping in the dark any more—we *measure* and *know*."

It never must be forgotten that testing is in reality a physical experiment, and these physical experiments are being conducted every day throughout the whole of our English telegraph system. Our cable electricians under the guidance of Sir William Thomson have carried this system of physical experiment to a high standard of perfection, and our Indian friends would do well to profit by their teaching.

Mr. Schwendler's explanation of the theory of the bridge is not clear, nor does his use of Kirchhoff's corollaries to Ohm's law much help the student. Indeed it is very doubtful whether his proof that the sensibility of the bridge method is greatest when the branch and the resistance are equal is true. At any rate in our practice we find that the more delicate the galvanometer of the bridge the more sensitive and the more accurate is our test.

The most valuable portion of Mr. Schwendler's book is his abstract of Ohm's classical paper, a translation of which is to be found in Taylor's "Scientific Memoirs," and also in his account of Kirchhoff's corollaries to this law.

The practice generally of line testing and testing for faults contains nothing new, but his chapter on natural currents, showing the effect of polarisation of earth plates and the presence of earth currents, is interesting.

He says, also "*Defective insulation at a few points* in a line is a fruitful source of currents. At all such points polarisation is produced by the working currents, in a manner precisely similar to that of the earth plates, by the same cause already alluded to, and to a degree dependent on the resistance and the position of the faults. These currents will be strongest in rainy weather, when the line is in contact with trees, when the insulators are covered with dew—in fine, under those circumstances which diminish the resistance of faults and promote electrolytic action.

"The stronger the working currents used, and the fewer the defective points, the stronger will be the polarisation currents.

"If these currents become very strong their direction may be reversed by sending for a short time a strong current with zinc to line; and, in such a case, this invariably indicates a single fault in the line or cable." This is a defect which we do not experience in England.

We find that (p. 66) "on all the lines in India positive signalling currents (copper to line) are used in order to have the greatest possible insulation of each line under all circumstances. Now, when measuring the insulation of a line with a positive test current, it is evident that the value obtained must give the insulation much too high, *i.e.*, higher than the line actually has when signals pass through it; because the signalling currents can only have a comparatively small oxidising effect on the line, since only a very small part can escape to earth in the different points of the line, while a positive testing current, the further end of the line being insulated, must all escape to earth at the defective points of the line. Again, when measuring the insulation of a line with a negative testing current, we get a value which gives the insulation of the line much too low, because negative signalling currents are never used. In the absence of any known law, which would give us how much too high the insulation of the line is obtained with a positive testing current, and how much too low with a negative testing current, we can do nothing better than to take the arithmetic mean of the measured values as representing the insulation the line probably has when signals are passing through it. Of this mean it may, however, be said that it must be always somewhat too low, for the very reason that negative signalling currents are never used, and therefore the arithmetic mean again of the *first mean* and the *positive measured value* would represent a value most probably approximating to the one which the line actually has when signals pass, and which alone is of practical interest and consequence to be known."

The latter part of the book is devoted to fault testing, *i.e.*, to the localisation of the positions of faults.

The book itself is a very valuable addition to the literature of the subject, but we doubt whether it will be of any practical use to our English electricians.

OUR BOOK SHELF

Sketches of Wild Sport and Natural History of the Highlands. By Charles St. John. Illustrated Edition. (London: Murray, 1878.)

MANY of our readers must be familiar with the inimitable "Sketches" of St. John, which has long ago achieved the position of a classic for both the sportsman and the naturalist. We do not know of any descriptions of sport to equal those that abound in these pages, in truthfulness, vigour, and genial humour. To the naturalist who loves to know the habits of an animal in its native haunts, the book must be a treasure; and now that Harrison Weir, Whymper, Corbould, Collins, and Elwes have adorned it with their art, the book should become a greater favourite than ever. No artist equals Whymper in his faithfulness to life in drawing animals. Every picture in the book—and there are about eighty of them—is a masterpiece in its way, and an impressive lesson in natural history. We need only say that the engraver is Mr. J. W. Whymper to convince our readers that the artists' charming work has been faithfully and skilfully rendered. No one can read a chapter of the book without being both refreshed and instructed.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

Paradoxical Philosophy

IT is strange to see a writer on philosophy like Mr. S. H. Hodgson, as well as physicists so exceptionally able as Prof. Clifford, and now Prof. Clerk-Maxwell, falling into the same *errors of observation* as more ordinary mortals. Neither the authors of the "Unseen Universe," nor any of the members of the Parodoxical Society, have, so far as I am aware, expressed the